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PATENT SPECIFICATION

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(19) THE PATENT OFFICE LONDON

(54) PROBE FOR USE IN DISPLACEMENT MEASURING APPARATUS

(71) We, ROLLS-ROYCE LIMITED, a British Company of 65, Buckingham Gate, London, SW1E 6AT (formerly known as Rolls-Royce (1971) Limited of Norfolk House, St. James's Square, London, SW1Y 4JR), and RENISHAW ELECTRICAL LIMITED, a British Company of Gloucester Street, Wooton under-Edge, Gloucestershire, GL12 7DN, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a probe for use in displacement measuring apparatus.

According to this invention there is provided a probe for use in displacement measuring apparatus, comprising a first rigid member connected by a pair of parallel leaf springs to a second rigid member connected by a second pair of parallel leaf springs to a third rigid member connected by a third pair of parallel leaf springs to a fourth rigid member, said three pairs of springs being positioned to allow, by flexing of said springs, relative motion of the first and fourth rigid members in three dimensions, said three pairs of leaf springs being positioned so that the space between the two springs of any one pair is shared with the space between the two springs of each of the other two pairs, one of said first and fourth rigid members being a support for a stylus, and the other one of said first and fourth rigid members being a support relative to which the stylus is movable in said three dimensions.

The invention brings about a space-saving arrangement of the springs.

Examples of apparatus according to this invention, being in the form of probes for use with an inspection machine, will now be described with reference to the accompanying drawings wherein:—

Fig. 1 is an elevation of an inspection machine including said probe.

Fig. 2 is a detail of the probe.

Fig. 3 is a sectional elevation of the probe.

Fig. 4 is a section on the line IV—IV in Fig. 3.

Fig. 5 is an elevation of a modified form of the probe.

Fig. 6 is a section on the line VI—VI in Fig. 5.

Fig. 7 is a circuit diagram.

An example of the use of the probe will at first be described with reference to Fig. 1. The probe, denoted 11, is supported by carriages 12, 13, 14 movable in the X, Y and Z directions of a right angle co-ordinate system. The movement of the carriages is indicated by respective digital displays 12A, 13A, 14A. The probe has a stylus 15 supported relative to a support or housing 16 for movement in the X, Y and Z directions and biased by a spring system (to be described) into a zero position relative to the housing. To measure a work piece 10 the appropriate carriage, say the carriage 13, is moved until a ball end 17 of the stylus touches a relevant surface 18 of the work piece. This disturbs the zero position of the stylus and results in a signal which is used to stop the display 13A of the carriage movement, the display then showing the position of said surface relative to a pre-selected datum. The carriage is stopped, either automatically or by the operator, as soon as possible after contact between stylus and work piece but a certain overrun of the carriage (Fig. 2) is of course unavoidable. In some applications the workpiece is measured by measuring the overrun of the probe and deducting this from the measurement of the position which the carriage had when stopped at the end of the overrun. However, the housing 16 may be fixed and the probe maybe used as a measuring device independently of the carriages 12, 13, 14.

STYLUS SUPPORT SYSTEM

Referring to Figs. 3 and 4, the stylus is generally rod-shaped and extends between the ball end 17 and a member 20 connected to the housing 16 by three pairs of leaf springs 22,

23, 24 inter-connected in series and arranged to flex in the X, Y and Z dimensions respectively. To this end the springs 22 lie in planes including the Y and Z dimensions, the springs 23 lie in planes including the X and Z dimensions, and the springs 24 lie in planes including the X and Y dimensions. The member 20 and a part 16A of the housing constitute end members of the in-series connection of the spring pairs.

In order to explain the spring arrangement each spring may be regarded as having a free and a fixed end, the fixed end being the end which, in the in-series connection, is nearest the housing 16. The connections between the springs may then be defined by saying that the springs 22 have free and fixed ends 22A, 22B secured respectively to the member 20 and an intermediate member 21, the springs 23 have free and fixed ends 23A, 23B secured respectively to the member 21 and a second intermediate member 25, and the springs 24 have free and fixed ends 24A, 24B secured respectively to the member 25 and a part 16A of the housing 16.

It may therefore be said that the springs 22 lie in planes perpendicular to the planes containing the springs 23, and the springs 24 lie in planes perpendicular to the planes containing the springs 22 and the planes containing the springs 23.

To make possible the connection between the springs 23, 24 to the second intermediate member 25, the latter has a part 25A connecting the fixed ends of the springs 23 and a perpendicular part 25B connecting the free ends of the springs 24, the fixed ends of the latter spring being connected by the part 16A.

In order to bring about a compact space-saving arrangement of the springs 22, 23, 24, these springs are grouped so that the space between the two springs of any one pair is shared with the space between the two springs of each of the other two pairs. This is achieved in the present example by arranging the springs 24 in planes respectively nearer the fixed and free ends 23A, 23B of the springs 23. Similarly, the springs 24 lie in planes respectively nearer the fixed and free ends 22A, 22B of the springs 22.

The end member 20, the part 16A and the intermediate members 21, 25 are each rigid members, that is they are of sufficient thickness not to undergo any significant deflection when the springs 22, 23 or 24 are flexed in operation. This is of particular importance in the part 25B which has to be rigid to avoid torsional deflection of the springs 24 under a force in the X or Y direction on the stylus.

As shown, the member 20 to which the stylus is secured is innermost in the box shape formed by the springs 22, 23, 24. Hence the part 25A and the adjacent spring 24 have holes 28, 29 for the stylus to extend to the exterior of the said box. But such holes would not be necessary if the stylus is connected to an edge of the member 20, as by being screwed into a hole 30 in the member 20 and one of the springs 22, to extend in the dimension X.

The springs 22, 23, 24 may be secured to the members 20, 21 25 and the housing 16 by brazing.

The springs 24 may, as shown, lie fully outside the extent of the springs 23 in the Z dimension but adjacent the respective ends 23A, 23B of the springs 23.

The springs may each be made of a single piece of sheet material.

MEASURING SYSTEM

As mentioned, the springs 22, 23, 24 bias the stylus into a zero position. This position is defined by the position adopted by the centre of the ball end 17 solely under the action of the springs and gravity, i.e. when there is no external force on the ball. Fig. 2 shows this zero position in full lines. Engagement with the face 18 of the work piece is shown as having resulted in a displacement Y1 in the Y dimension as shown in dotted lines. Due to the way in which the shape of the springs, in this case the springs 23, changes during the displacement Y1 there inevitably occurs also a secondary displacement Z1 in the Z dimension. Generally, a displacement in any one dimension results in a secondary displacement in at least one of the other dimensions, and a true reading of the co-ordinate position of the ball end 17 requires that all three dimensions, or two dimensions if only two dimensions are required, are sensed at the same time.

The measuring system comprises (Figs. 3, 4) an iron mass 40 secured to the member 20 by an extension 41 so as to accompany any movement of the stylus 15. The mass 40 has surfaces 42, 43, 44 respectively facing in the X, Y and Z dimensions and respectively confronting three sensors or transducers 45, 46, 47 mounted on a part 16B of the housing 16. Each transducer comprises an inductance bridge (Fig. 7) whereby to sense a displacement of the mass in the respective dimension X, Y or Z.

Each bridge comprises coils A, B, C, D of which the coils A, B are located on the housing part 16B in proximity with the respective surface 42, 43 or 44, and the coils A, B are connected through a plug 48 to a convenient stationary location where the remainder of the bridge is situated. The sensing of, for example, displacement in the Y dimension occurs because the movement of the ball end 17 changes the distance between the surface 43 and the coils A, B of the transducer 46 and thereby changes the balance of the relevant bridge. Only movement of the surface 43 in the Y dimension is sensed. Movement in the X or Z dimensions does not affect the transducer

46 because such movements do not affect the distance between surface 43 and the adjacent coils A, B. To ensure this condition the surfaces 42, 43, 44 should be reasonably flat and they must of course be perpendicular to the respective X, Y and Z dimensions. The bridges are in turn connected to respective display units 49, 50, 51 or to a computer 52 for relating the transducer outputs to the position of the carriages 12, 13, 14. In the present example the coils A, B of the respective bridges are situated both at one side of the mass 40.

In a modification (Figs. 5, 6) the coils A, B are situated at opposite sides of the mass. As shown, the mass is in the form of a cube 140 surrounded by a chamber 116B having walls supporting the coils A, B of the respective transducers 45, 46, 47 at opposite sides of the cube 140. The cube is connected to the stylus 15 by a U-shaped blade 141 secured between the extension 41 and an edge of the cube so as to lie clear of the three pairs of oppositely facing surfaces of the cube. This arrangement of the coils improves linearity of read-out.

The matter described with reference to Figs. 5 to 7 is claimed in our co-pending application No. 20017/75 (Serial No. 1,551,217).

WHAT WE CLAIM IS:—

1. A probe for use in displacement measuring apparatus, comprising a first rigid member connected by a pair of parallel leaf springs to a second rigid member connected by a second pair of parallel leaf springs to a third rigid member connected by a third pair of parallel leaf springs to a fourth rigid member, said three pairs of springs being positioned to allow, by flexing of said springs, relative motion of the first and fourth rigid members in three dimensions, said three pairs of leaf springs being positioned so that the space between the two springs of any one pair is shared with the space between the two springs of each of the other two pairs, one of said first and fourth rigid members being a support for a stylus, and the other one of said first and fourth rigid members being a support relative to which the stylus is movable in said three dimensions.

2. Probe according to claim 1 wherein the two springs of said third pair of springs lie at opposite sides of the assembly comprising said first and second pair of springs and said first and second rigid member.

3. Probe according to claim 1 wherein the assembly comprising said first and second pair of springs and said first and second rigid member lies between the two springs of said third pair of springs.

4. Probe according to claim 1 wherein said third rigid member has a part adjacent said first rigid member and said second pair of springs is connected between said second member and said part.

5. A probe according to claim 1 wherein said third rigid member has a first part situated adjacent the first rigid member, wherein said fourth rigid member and a second part of the third rigid member are situated at opposite sides of the assembly comprising said first and second pair of springs, said second pair of springs being connected between said second rigid member and said first part of the third rigid member, and said third pair of springs being connected between said second part and said fourth rigid member.

6. Probe according to claim 4 wherein the assembly comprising said first and second pair of springs and said first and second rigid members is situated between said second part of the third rigid member and said fourth rigid member.

7. Probe according to claim 5 wherein said first part of the third rigid member lies between said first rigid member and one of the springs of said third pair.

8. A probe for use in displacement measuring apparatus substantially as described herein with reference to Figs. 1 to 4 of the accompanying drawings.

For the Applicants,
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Chartered Patent Agent.

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Fig.1.

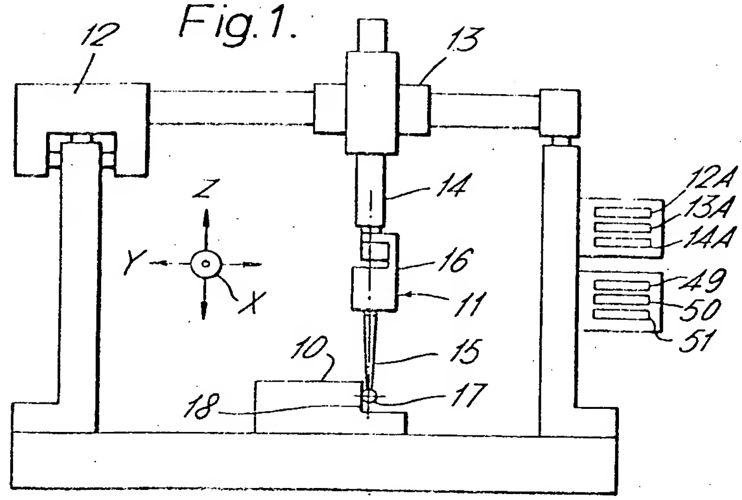

12
13
14
Z
Y
X
16
11
12A
13A
14A
49
50
51
10
15
18
17

Fig.2.

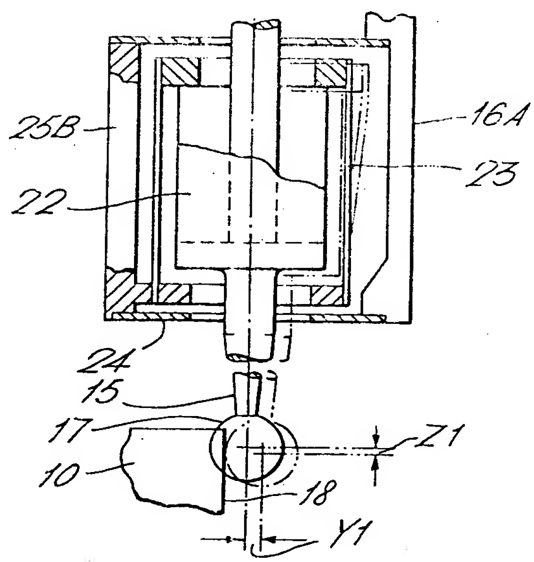
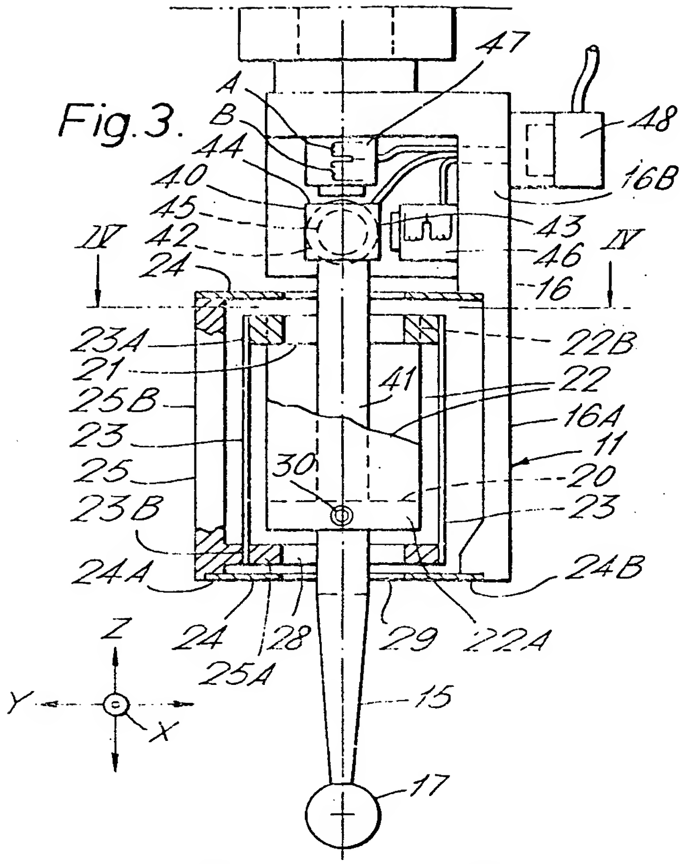

25B
16A
23
22
24
15
17
Z1
10
18
Y1

Fig.3.


47
A
B
44
40
45
42
IV
24
48
16B
43
46
IV
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25B
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25
23B
24A
22B
41
22
16A
11
30
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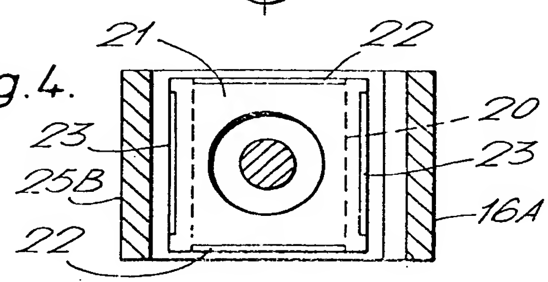
24B
24
28
25A
29
22A
Z
Y
X
15
17

Fig.4.


21
22
20
23
25B
23
16A
22

1551218 COMPLETE SPECIFICATION

4 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 3

Fig.5.

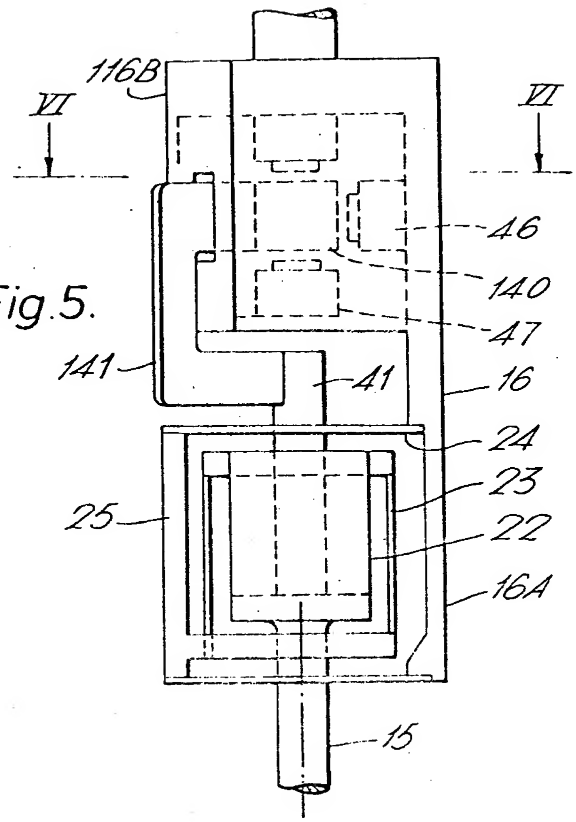


Fig.6.

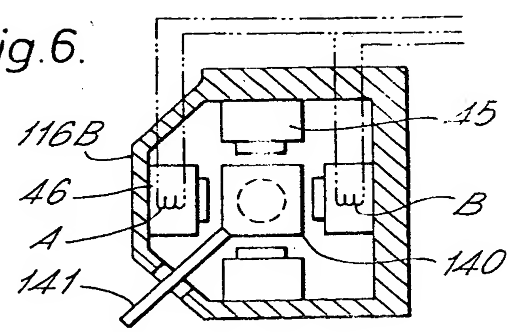


Fig. 7.